

INDOT Intelligent Design and Construction (IDC)

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2019 Purdue Road School

March 6, 2019

Mission Statement

- The use of intelligent 3D CAD models to support the lifecycle of transportation assets (roads and bridges) that provides predictive analysis and reporting capabilities that is data driven and allows the agency to make better operational and strategic management decisions.

The Business Opportunity



Figure 5.2 Asset data flow in the current practice at INDOT.



Figure 5.3 The suggested data flow.

IDC Areas of Emphasis

- Intelligent Design / Automated Machine Guidance (AMG)
 - Transition from 2D plan sets to 3D design models
- e-Construction
 - Transition to Paperless construction
- Asset Management
 - Better utilization of data from Design and Construction for Operations and Maintenance

e-Construction and Partnering FHWA Peer Exchange

- Hosted FHWA e-Construction and Partnering Peer Exchange
 - August 2018
 - Topics
 - 3D CAD Model as Contract Document
 - Utah DOT
 - e-Ticketing for Materials Delivery
 - Pennsylvania DOT
 - ROI e-Construction
 - Oregon DOT
 - ROI 3D CAD Models
 - Wisconsin DOT

Asset Management

- Progress to date:
 - RFID Tag Proof of Capability study
 - September 2017
 - Small Culverts, Panel and Sheet signs
 - Presented the results to the INDOT asset owners
 - WMS and ESRI Roads and Highways integration
 - Ongoing to overcome integration issues
 - Transportation Asset Management Plan
 - Draft version released April 2018
 - FHWA approved draft version Fall 2018

Intelligent Design / AMG

- Progress to date:
 - SS4 OpenRoads migration from SS2 InRoads
 - Completed training for INDOT staff August 2016
 - March 2017, SS2 InRoads removed from user computers except those working on older projects
 - Central Office Road Design has completed projects using SS4 OpenRoads creating 3D Models
 - Provided ContextCapture training to INDOT Land and Aerial Survey Office (LASO)
 - December 2017, Bentley Systems, Inc.
 - ContextCapture allows UAV / Drone / LiDAR / Conventional Survey data to be combined to create a 3D Mesh
 - Provided Subsurface Utility Drainage Analysis (SUDA) best practices and software overview to INDOT Hydraulics and Road Design groups
 - January 2018, Bentley Systems, Inc.
 - SUDA is 3D modeling software for utilities

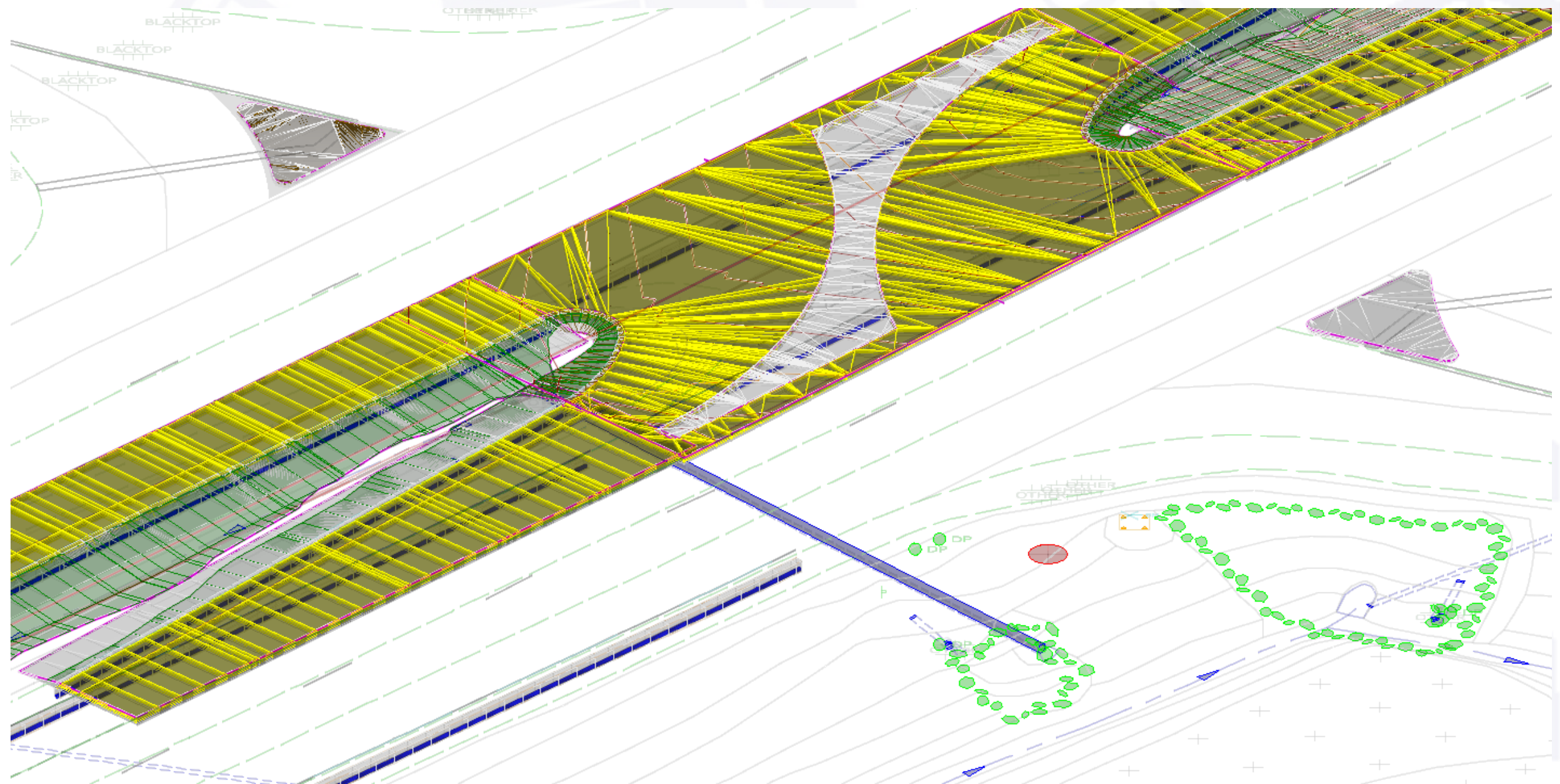
Intelligent Design / AMG

- SS4 OpenRoads
 - SS4 OpenRoads migration from SS2 InRoads
 - Design in SS4 began July 2016 select Central Office Road Designers
 - Migration of existing projects less than seamless
 - Existing projects in SS2 remain in SS2
 - IRD point controls often lost in translation
 - New designs in SS4
 - Improved 3d Design
 - Improved Cross Sections
 - Non-perpendicular template areas much improved
 - Better Visualization
 - Steps on the Path to Connect Edition ORD

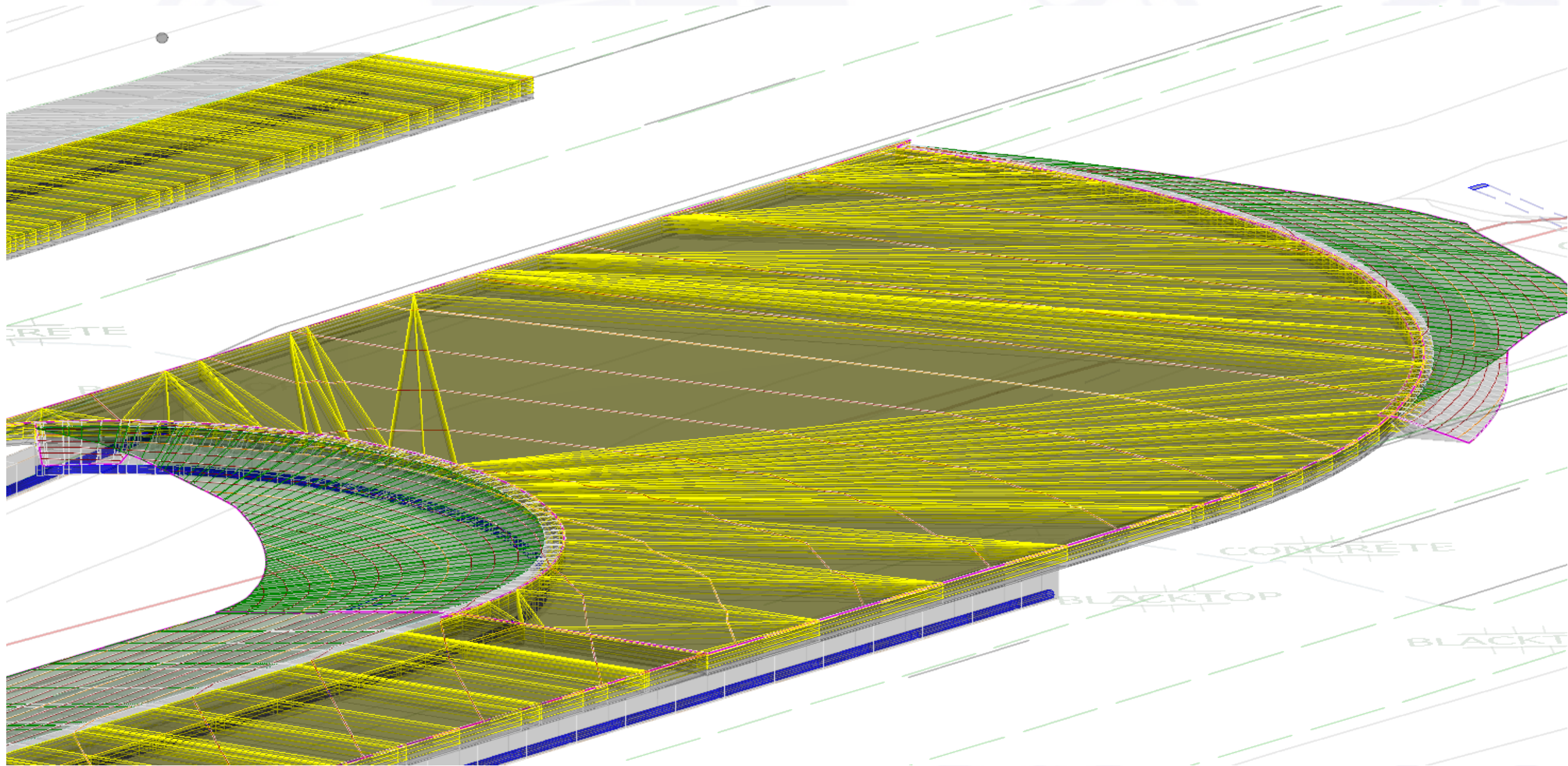
Intelligent Design / AMG

- Example 3d Design model
 - Intersection Improvement
 - Geospatially located Survey Data
 - Typical template design in 3d
 - Turning areas modeled
 - Simplified irregular design areas
 - Surface Templates and Terrain Models
 - Underdrain and Drainage Tie in
 - Accurate models of both existing and proposed underdrains
 - Simplified special grade calculation
 - Tie in to existing

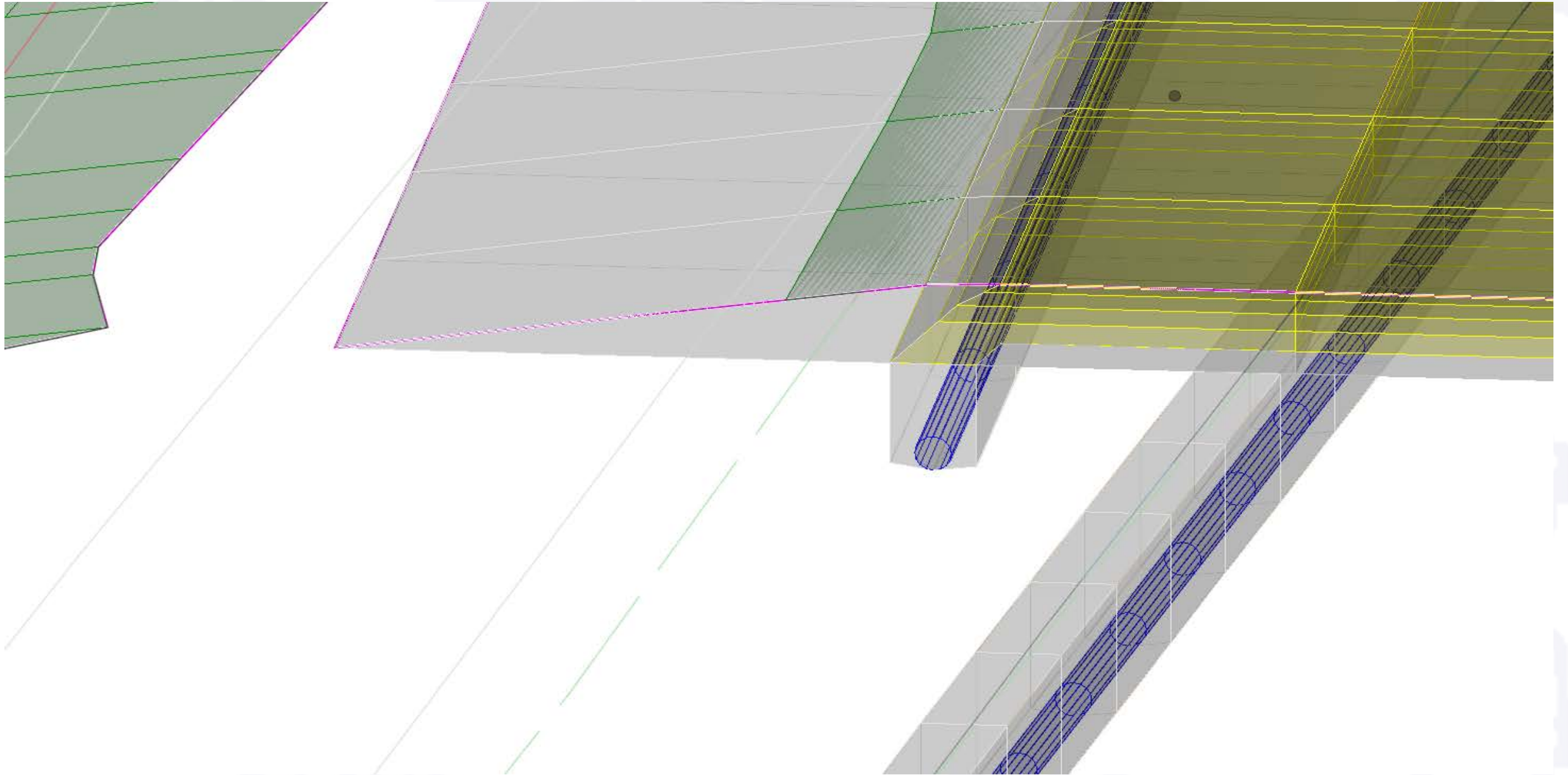
Intelligent Design / AMG



Intelligent Design / AMG



Intelligent Design / AMG



Intelligent Design / AMG

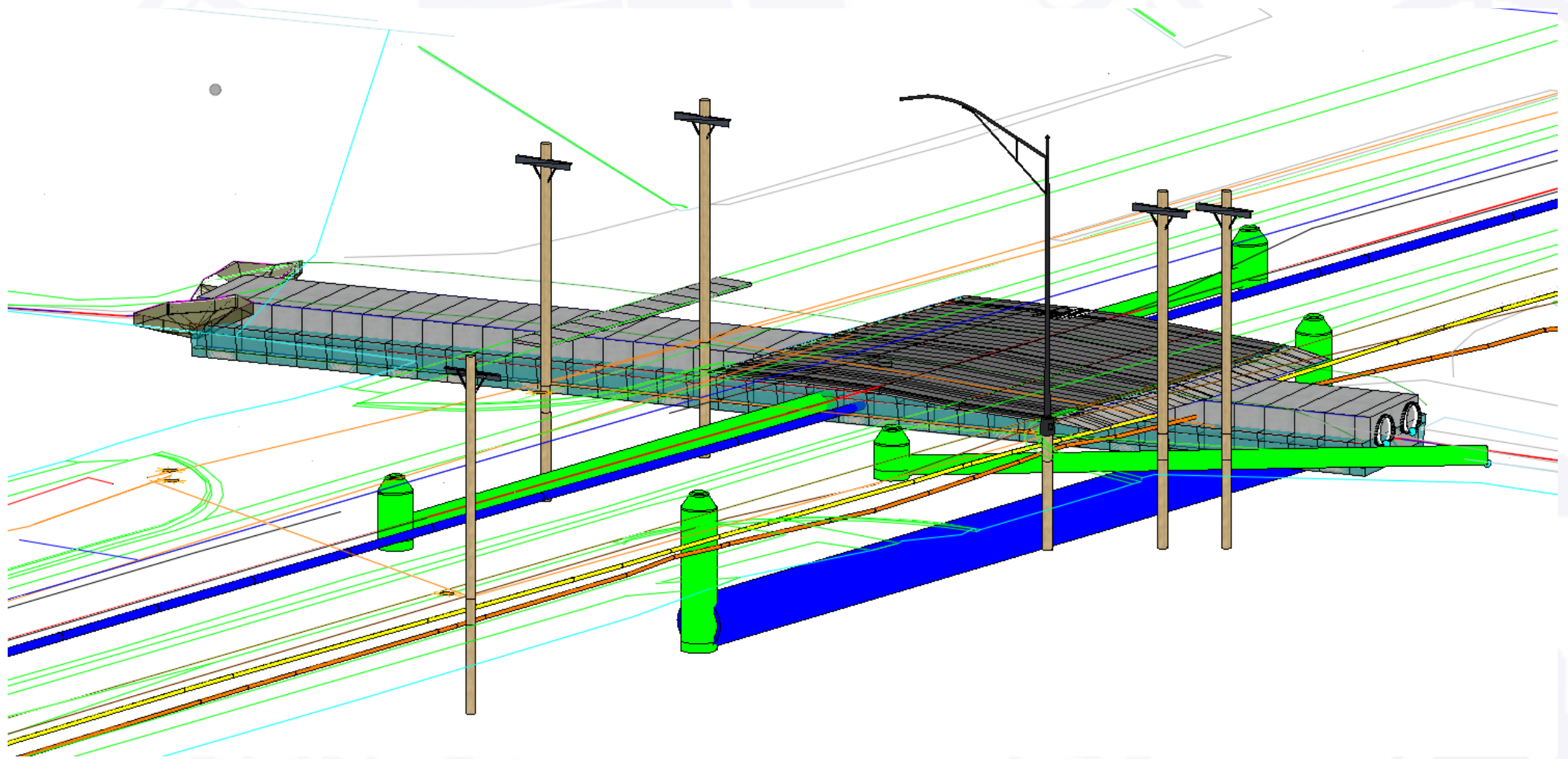
- SS4 SUDA

- Provided Subsurface Utility Drainage Analysis (SUDA) best practices and software overview to INDOT Hydraulics and Road Design groups
 - January 2018, Bentley Systems, Inc.
 - SUDA is 3D modeling software for utilities
- Using lessons learned from best Practices Analysis
 - Aware of the large configuration effort required, we did the following simple alternative
 - Implemented SUDA on unofficial pilot project
 - Local configuration of SUDA for 3d location
 - Clash Detection was primary goal
 - Hydraulic flow modeling not considered

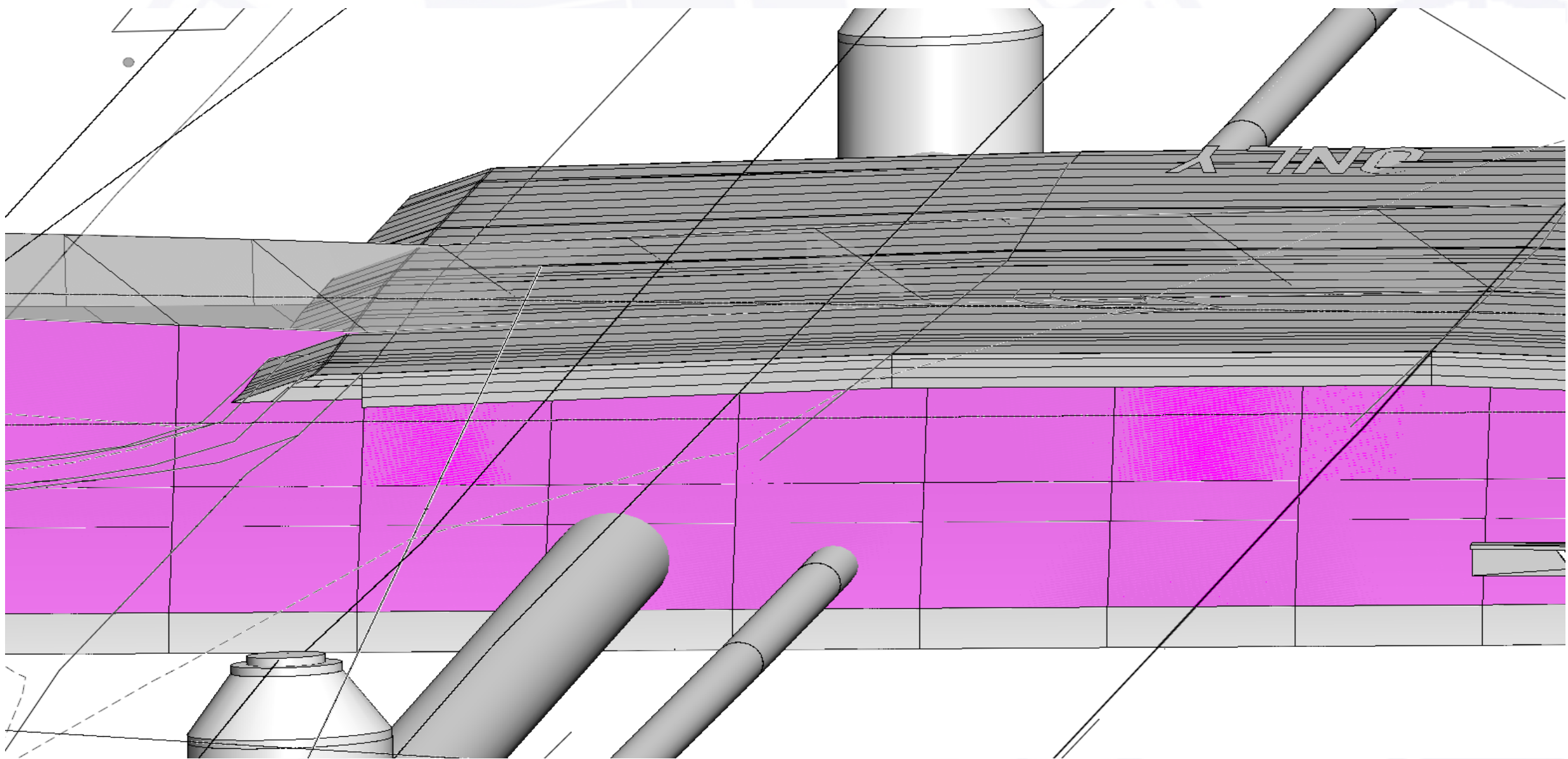
Intelligent Design / AMG

- Example SUDA
 - Urban small structure replacement
 - Numerous Existing Utilities
 - Proposed Structure larger than existing
 - Existing Dual pipe arches failing
 - Reinforced Concrete Box replacement
 - Possible Conflicts Identified
 - Sanitary Sewer 24" immediately underneath existing pipes
 - Sewer Interceptor backfill loss under structures
 - Fiber likely runs under (through new) structures
 - Gas likely runs under (through new) structures
 - Water likely conflicts with new structure
 - Power Pole foundation in close proximity to structure excavation area

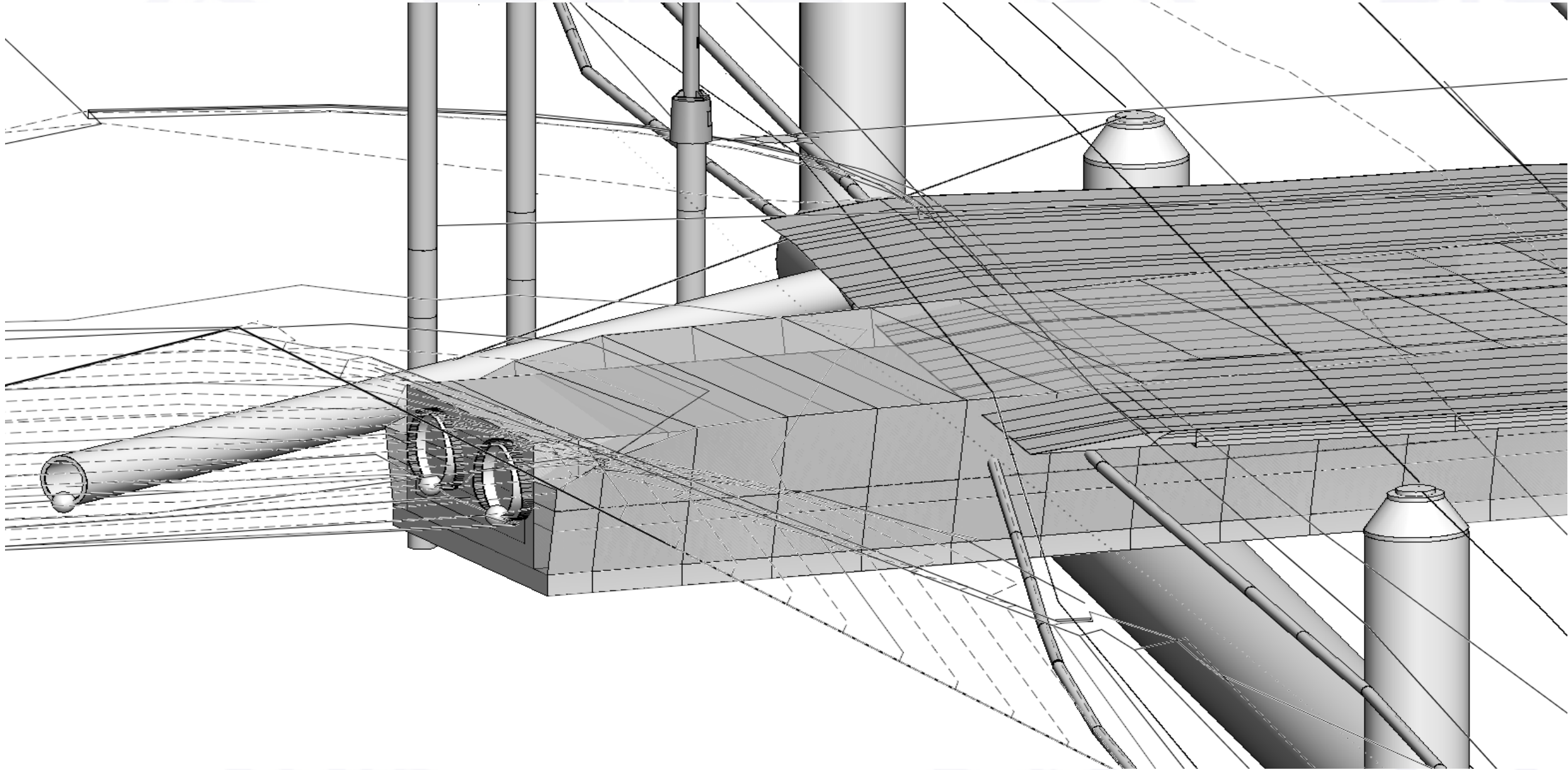
Intelligent Design / AMG



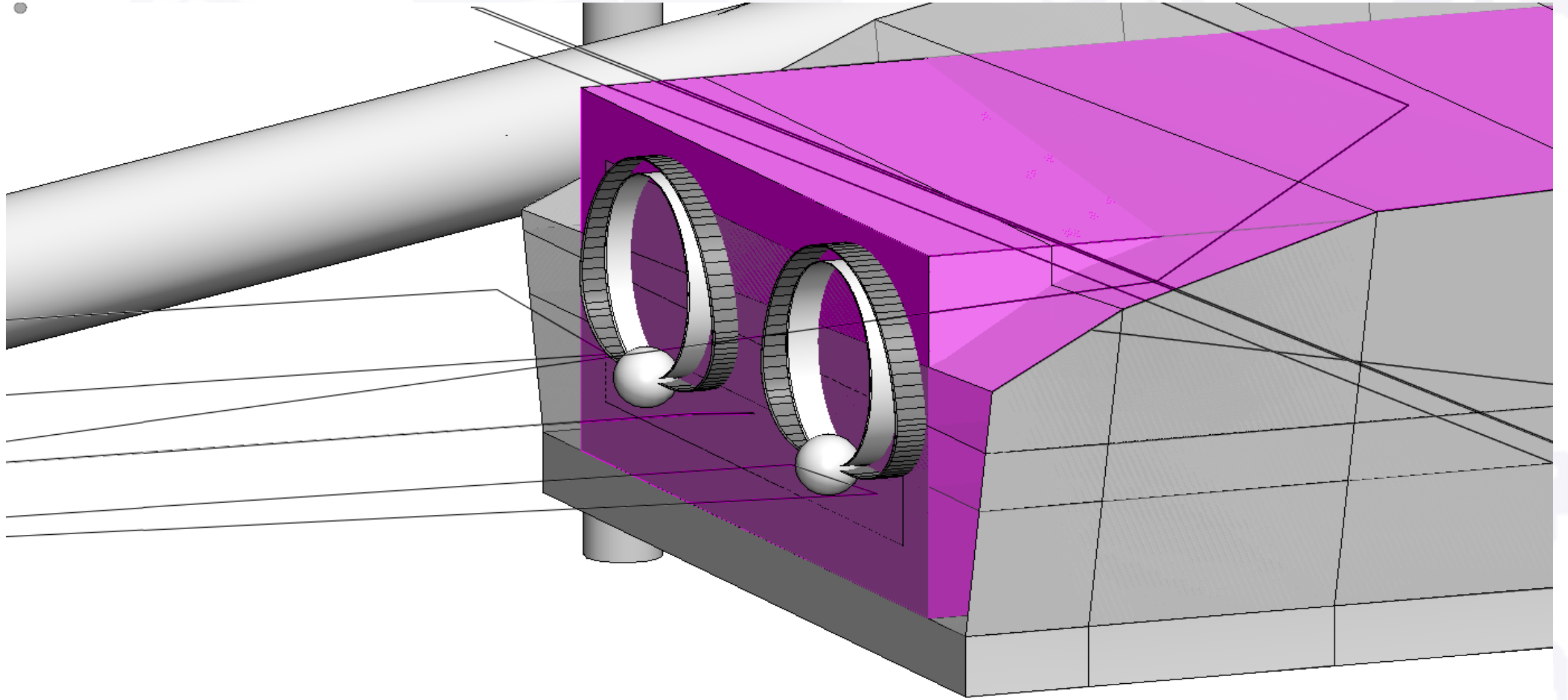
Intelligent Design / AMG



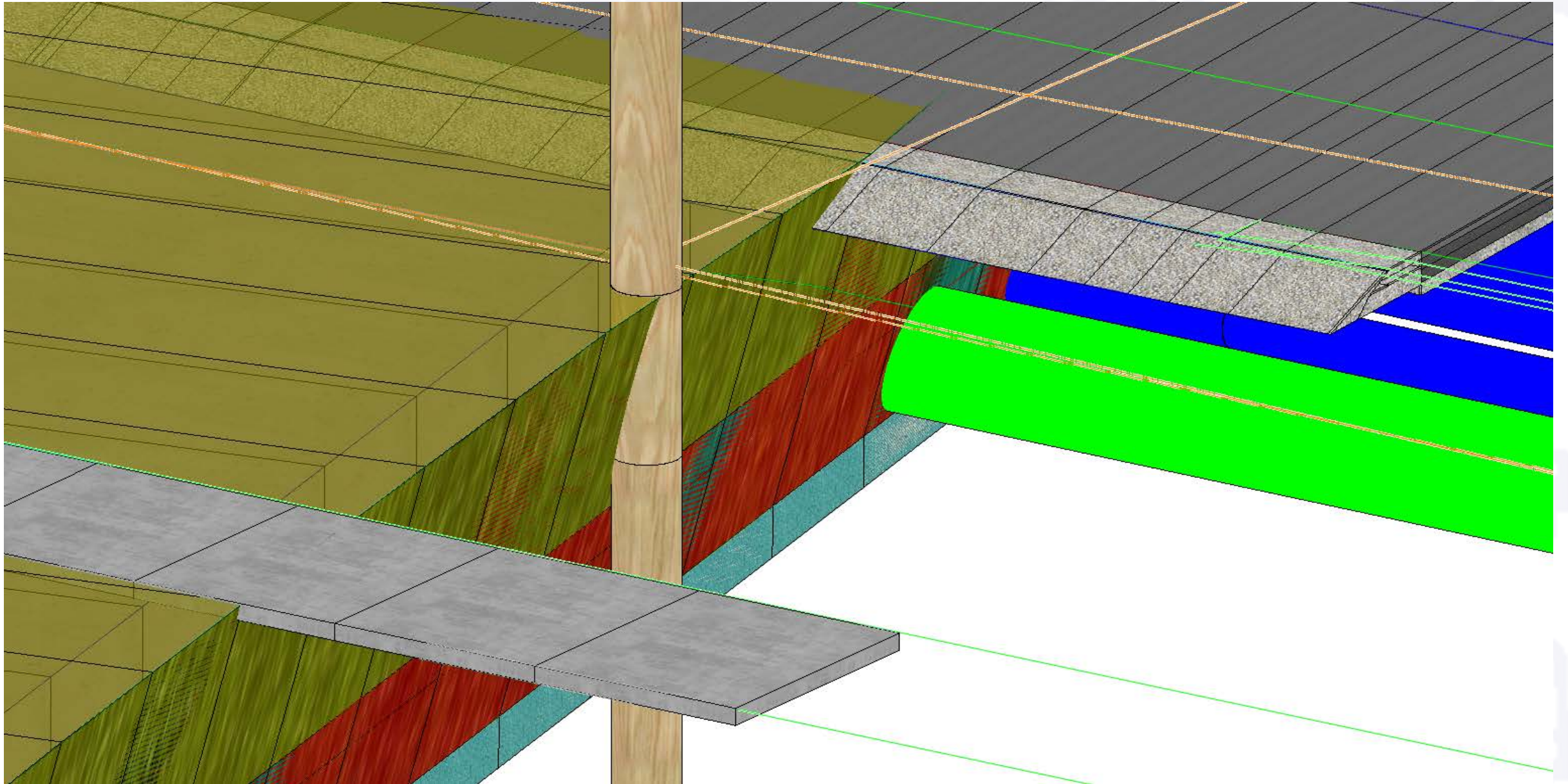
Intelligent Design / AMG



Intelligent Design / AMG



Intelligent Design / AMG



Intelligent Design / AMG

- Ongoing Efforts
 - Improved Patching Table
 - Locate Patching Geographically
 - Remove guesswork for Field Employees
 - Leverage ESRI ArcCollector App
 - Better utilization of Pavement distress scanning data
 - LiDAR
 - Make use of Oregon DOT lessons
 - Improved accuracy
 - Better Design tolerances
 - Cost savings with less change orders
 - Bentley Open Roads Designer ORD
 - Workspace Migration
 - Plan Pilot project
 - Implementation

eConstruction Projects

Intelligent
Design and
Construction

AASHTOWare
Project

PWL Wizard

eFCR

HMA Tracker

eConstruction Projects

Quality
Checklists

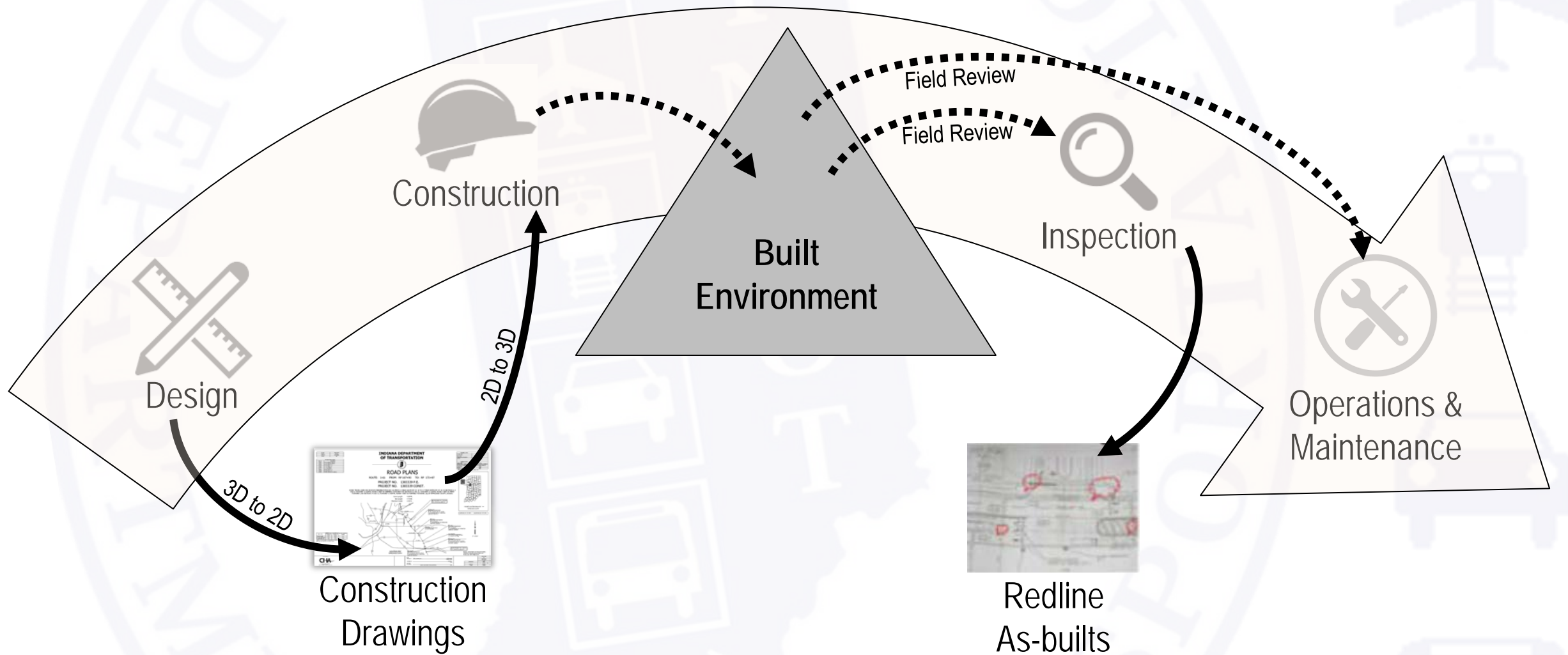
eTicketing

OnDemand
Training

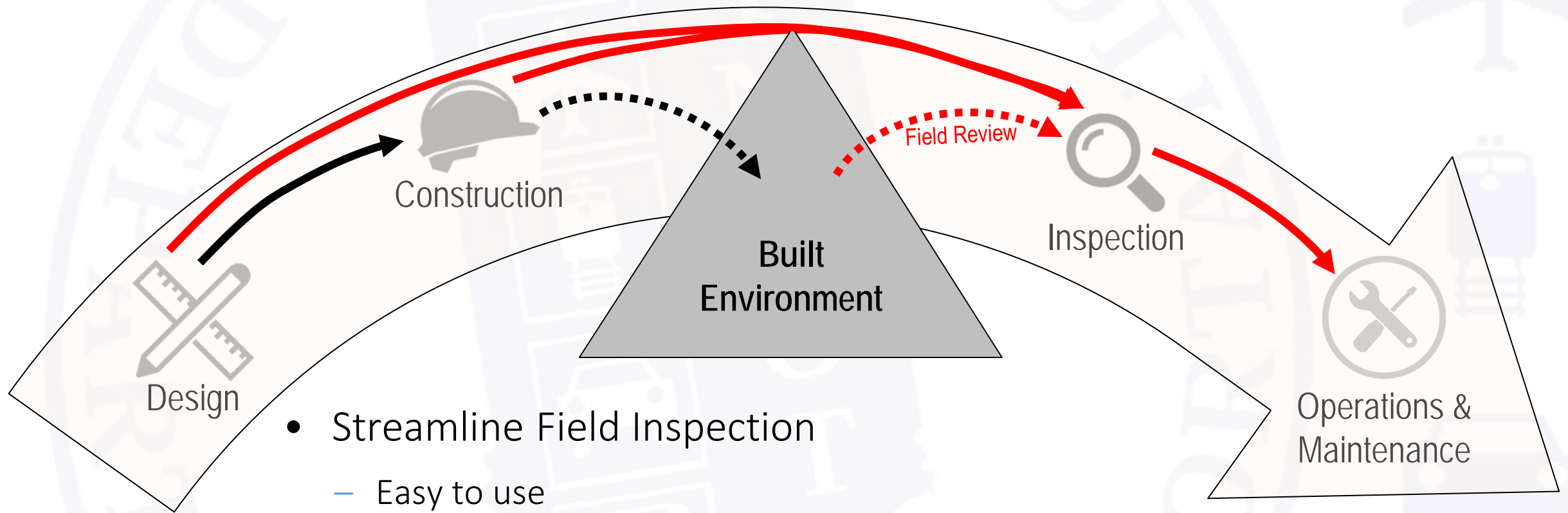
GPS/Rover
Grade Control

Digital As-
Builts/Asset
Management

Legacy Project Information Flows



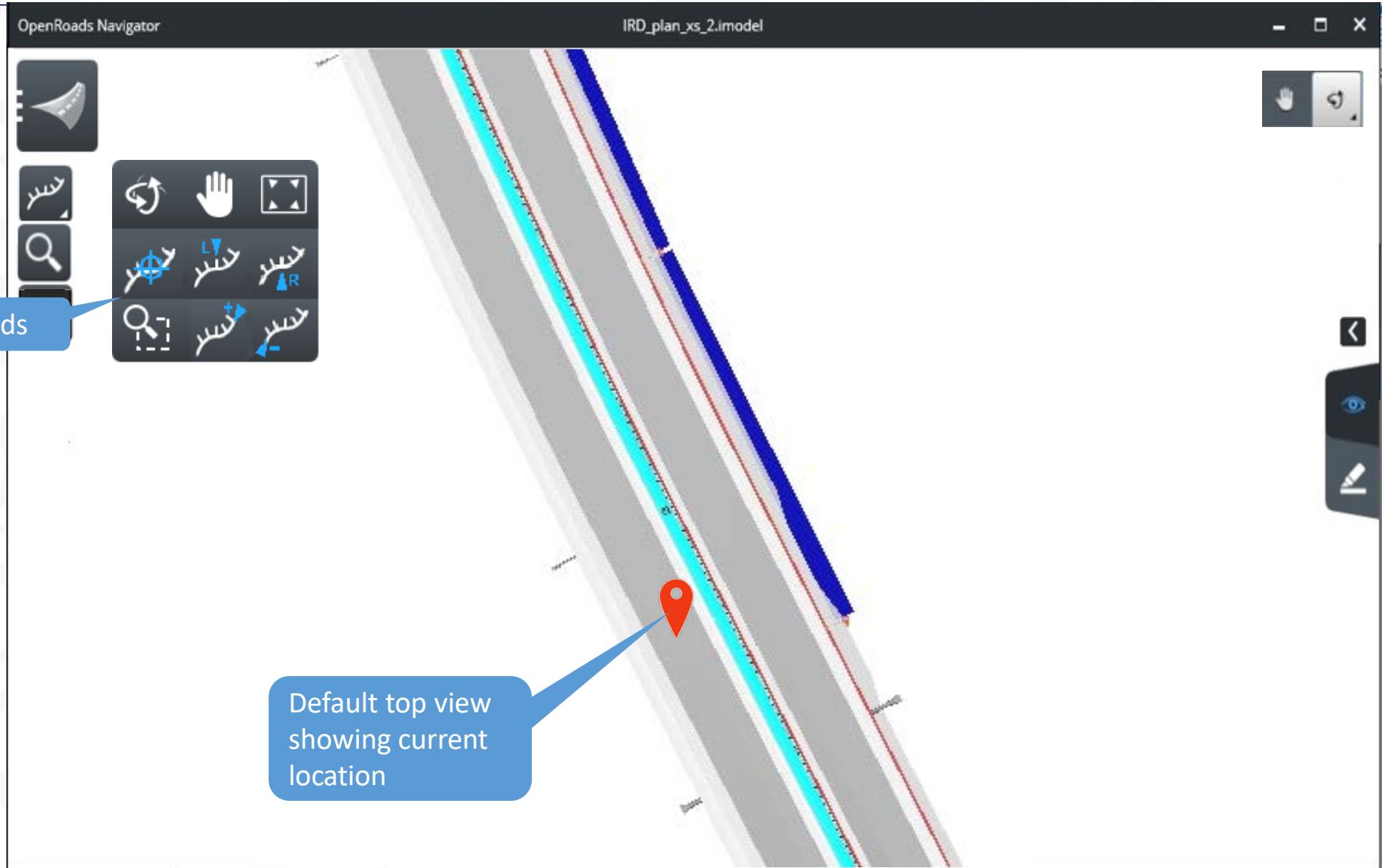
Information Mobility Goals



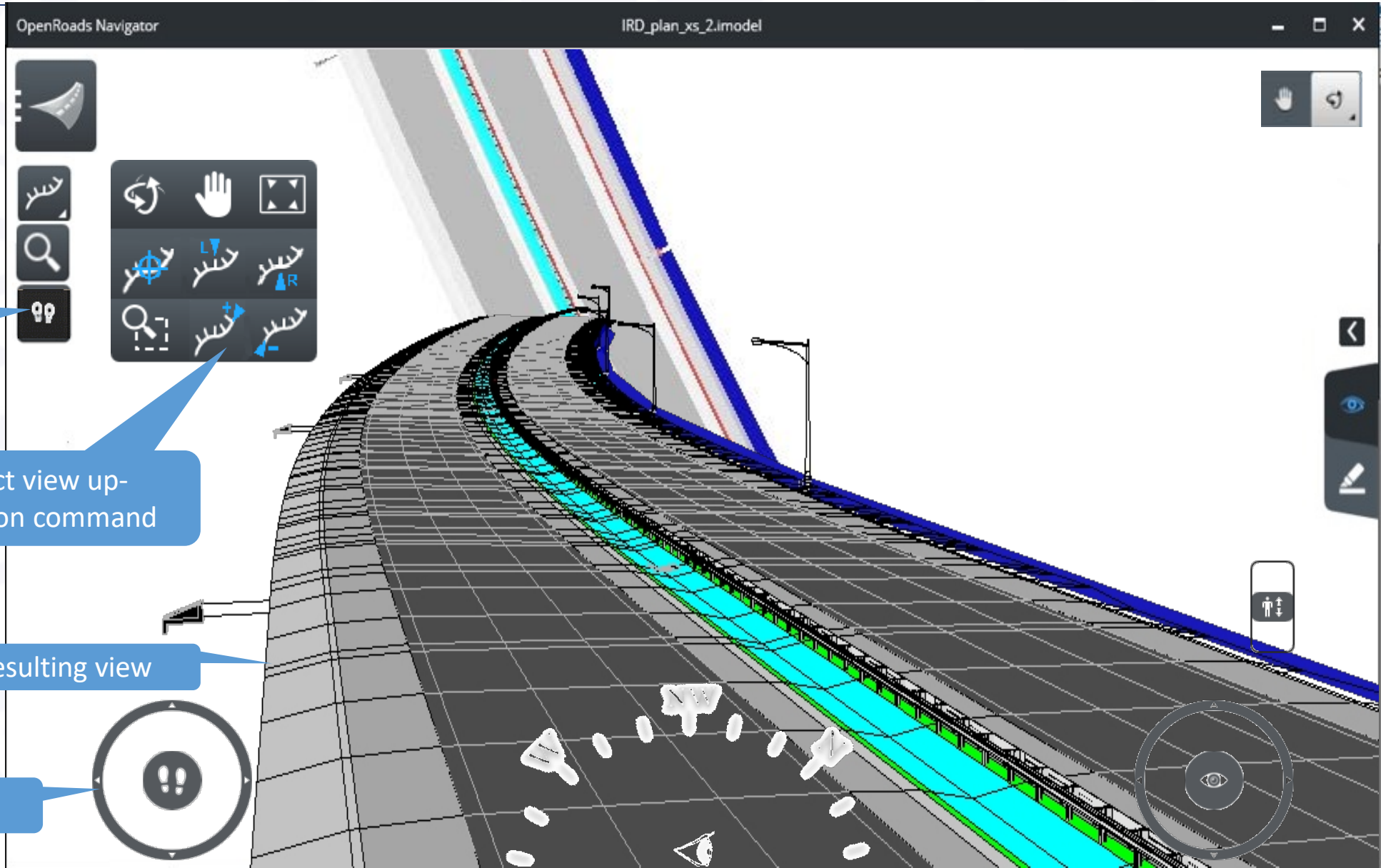
- Streamline Field Inspection
 - Easy to use
 - Click onto graphics to access specs, check lists & forms
 - Graphical indexing and status visualization of all inspections
 - Queries, benchmarking, audits, litigation research and analytics
 - Automated population of Asset Management databases

Construction Inspection

Field Review – View Settings



Field Review – View Settings



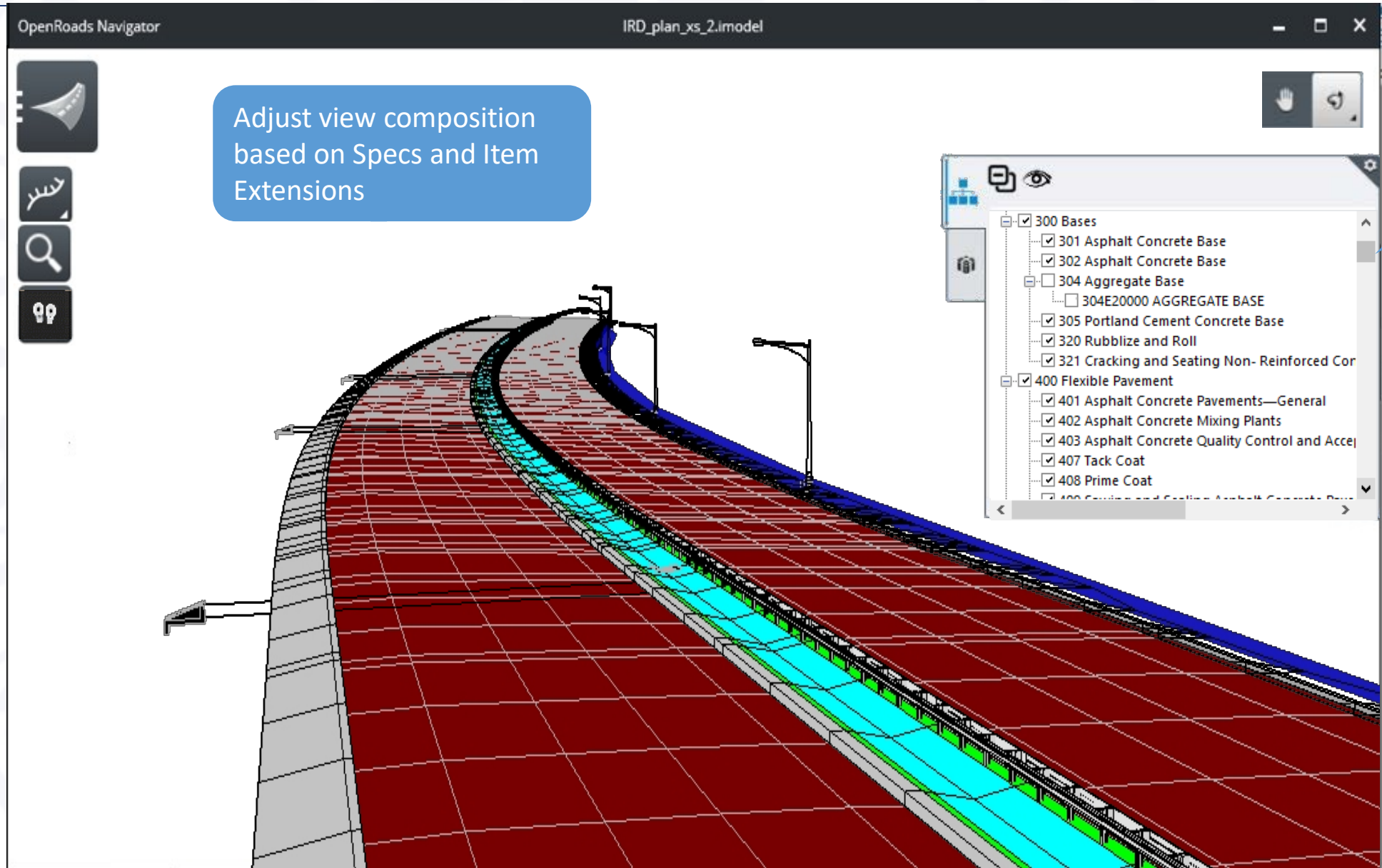
Walk icon

Select view up-station command

Resulting view

Walk controls

Field Review



Field Review

OpenRoads Navigator IRD_plan_xs_2.imodel

611E10400-24" CONDUIT, TYPE B

Admin ▾
Installation Plan >

Field ▾
Excavation >
Installation >
Backfill >

Admin ▾
Post Installation >

Inspection regimen appropriate for component type

SS1: 611E10400	
Location Begin Station	282+99.50
Location End Offset	-89.75
Location End Station	282+99.50
Pipe Diameter	24
Pipe Shape	circle
Quantity	87
Quantity Unit	LF
Structure Begin Invert Elevation	670.37
Structure Begin Name	DI-501
Structure End Invert Elevation	669.76
Structure End Name	HW-

Pull out Inspections panel

Field Review – Documentation

OpenRoads Navigator IRD_plan_xs_2.imodel

Cancel Documentation Save

ITEM 611 PIPE CULVERTS, SEWERS, DRAINS, AND DRAINAGE STRUCTURES

- 611.01 Description
- 611.02 Materials
- 611.03 Definitions
- 611.04 Submittals
- 611.05 Excavation
- 611.06 Bedding and Backfill
- 611.07 Laying Conduit
- 611.08 Joining Conduit
- 611.09 Exterior Coatings and Membrane Waterproofing
- 611.10 Drainage Structure Construction
- 611.11 Field Paving of New or Existing Conduit
- 611.12 Performance Inspection
- 611.13 Conduit Evaluation
- 611.14 Drainage Structure Evaluation
- 611.15 Force Settlements
- 611.16 Method of Measurement
- 611.17 Basis of Payment

611.01 Description. This work consists of constructing conduits, and constructing and reconstructing drainage structures. This work also includes pre... ports and other... size or one size... is designed for... e performance... alic capacity... umish conduit... conforming to any of the material requirements listed for that conduit type. All listed

Inspections
611E10400-24" CONDUIT, TYPE B

Admin v
Installation Plan v
Quality Form

Field v

Item 611 Pipe

611.02 Cond TBD

611.02 Bedding & Backfill material: TBD

611.04 A Calculations TBD

New Inspection

Select bookmark to access specs

Save

Expand

Quality form for Admin Installation Plan automatically appears without selecting because only option currently available

Field Review – Admin > Installation Plan

Use markers, data points & key-ins to graphically define inspection limits.

First Point Station  No Portion Entirety

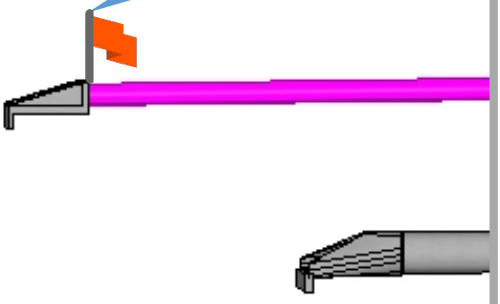
Could alternately select entire component length

Inspections
611E10400-24" CONDUIT, TYPE B

Admin v
Installation Plan v
Quality Form

Field v
Excavation v
Quality Form
Quantity Form
Worksheet Form

Marker



Item 611 Pipe

611.02 **Conduit material:** Is the conduit material listed in the installation plan appropriate for the Type?

611.02 **Bedding & Backfill material:** Are all material listed in installation plan for backfill and bedding included in 611.02? Ensure Granular Structural Backfill 703.11 is proposed for Structural Backfill to 12" above conduit.

611.04 A **Calculations** Are shop drawings or revised drainage calculations required as prescribed in 611.04 A? Load rating calculations are required for all structures with a 10-foot or larger span. Submit calculation to District Bridge Engineer or Office of Structural Engineering. Required

611.04 B **Contractor provided installation plan** Did the Contractor provide an installation plan for all conduits and drainage structures? Ensure that the Contractor used CA-P-1A and CA-P-3A as the installation plan. No generic installation plans are acceptable.

General Comments

Photos

Fill out and save form



Field Review – Admin > Installation Plan

OpenRoads Navigator IRD_plan_xs_2.imodel

Inspections
611E10400-24" CONDUIT, TY

- Admin** ▾
 - Installation Plan ▾
 - Quality Form ▾
 - 14-Jan-19
- Field** ▾
 - Excavation ▾
 - Quality Form
 - Quantity Form
 - Worksheet Form
 - Installation >

Green color indicates that all checklist items on quality form for Installation Plan passed

Graphical definition of inspection limits not required in this case as the entire component length is default when saving form

Can change inspection form and limits on the day of inspection. Afterward, the inspection is locked.

Field Excavation, Installation and Backfill now available for inspection. Field Post Installation remains unavailable

NextLevel INDIANA

Field Review – Field > Excavation

OpenRoads Navigator

IRD_plan_xs_2.imodel

Second Point
Station Length 36

Keyin length

Indicator placed at defined length

Red color denotes failed inspection item

Save form

Inspections
611E10400-24" CONDUIT, TYPE B

- Admin ▾
- Installation Plan ▾
- Quality Form >
- Field ▾
- Excavation ▾
- Quality Form >
- Quantity Form
- Worksheet Form

Item 611 Pipe

plan at their own risk.

CA-P-1 & CA-P-3 forms
611.04 C Is the Contractor filling out the most up to date CA-P-1 and CA-P-3 forms during installation of each conduit run and drainage structure? These forms are required to be submitted before the start of the next work day. Do not compensate for Work prior to receiving the completed inspection forms.
Pass ▾

Unsuitable material
611.05 Was any unsuitable material encountered during excavation? If so, note locations of overexcavation. Muck la
Pass ▾

Drainage maintenance
611.07 Did the Contractor maintain flows and drainage at all times during installation of the conduit? Document any flooding issues occurring during construction. Muck tr
Fail ▾

General Comments

Field Review – Field > Installation

The screenshot displays the OpenRoads Navigator interface for a field review of 'Item 611 Pipe'. The central view shows a 3D model of a pipe installation with a red crosshair indicating the current inspection point. On the left, a navigation pane shows a tree view with 'Inspections' expanded to '611E10400-24" CONDUIT, TYPE B', and sub-items for 'Admin', 'Installation Plan', 'Field', 'Excavation', and 'Installationy'. Below this, a list of forms is shown, with 'Item 611 Pipe' selected. A blue callout bubble points to the 'TBD' status in the 'Installation plan adherence' row, stating: 'Fill out form. Note TBD indicates incomplete.' On the right, a detailed form for 'Item 611 Pipe' is displayed, containing various inspection items with dropdown menus for status (Pass, TBD, N/A) and text input fields for comments. A 'Save' button is visible in the top right corner of the form area. A hand cursor icon is positioned over the right side of the form.

Item ID	Question	Status	Comments
611.04 B	Installation plan adherence	TBD	
611.04 C	CA-P-1 & CA-P-3 forms	TBD	
611.06	Geotextile fabric	TBD	
611.07	Drainage maintenance	N/A	
611.07	Cutting conduits	TBD	was not able to complete
611.07	Outlet end to inlet	Pass	No allowances required
611.08 A-D	611.08 A-D	Pass	
611.09	Waterproofing	TBD	
611.11	Field paving	N/A	
611.12	Visual inspections	Pass	No deficiencies observed

Other Forms: Field > Installation > Worksheet Form

Inspections
611E10400-24" CONDUIT, TYPE B

Admin >
Field V
Excavation >
InstallationV
Quality Form
Quantity Form
Worksheet Form 1
Worksheet Form 2

Backfill >
Admin >

Item 611 Pipe Installation Worksheet (1 of 2)

Date ContID AltID

PLN Project No.(Part Code)

Item No Item Desc

Location Co/Rt/Sec

Contractor: Plan Page

Balloon Ref.# Pipe Material

Type of Pipe

Pipe Markings

Type of Joints (611.08) Joints Installed Satisfactorily? Yes No

Materials: All tested and approved prior to incorporation into the project.

Balloon Ref. #(s)

Station to Station

Plan Qty. LF (meters)

Remarks:

Daily Total Field Measured: LF (meters)*

Remarks:

Item 611 Pipe Installation Worksheet (2 of 2)

W = Width of trench at Top of Pipe.

B = Thickness of bedding under pipe.

T = Outside diameter of pipe to trench wall.

S = Depth of bedding.

OD = Outside diameter of pipe.

Plan Begin Invert Elev. = Field Inv. =

Plan End Invert Elev. = Field Inv. =

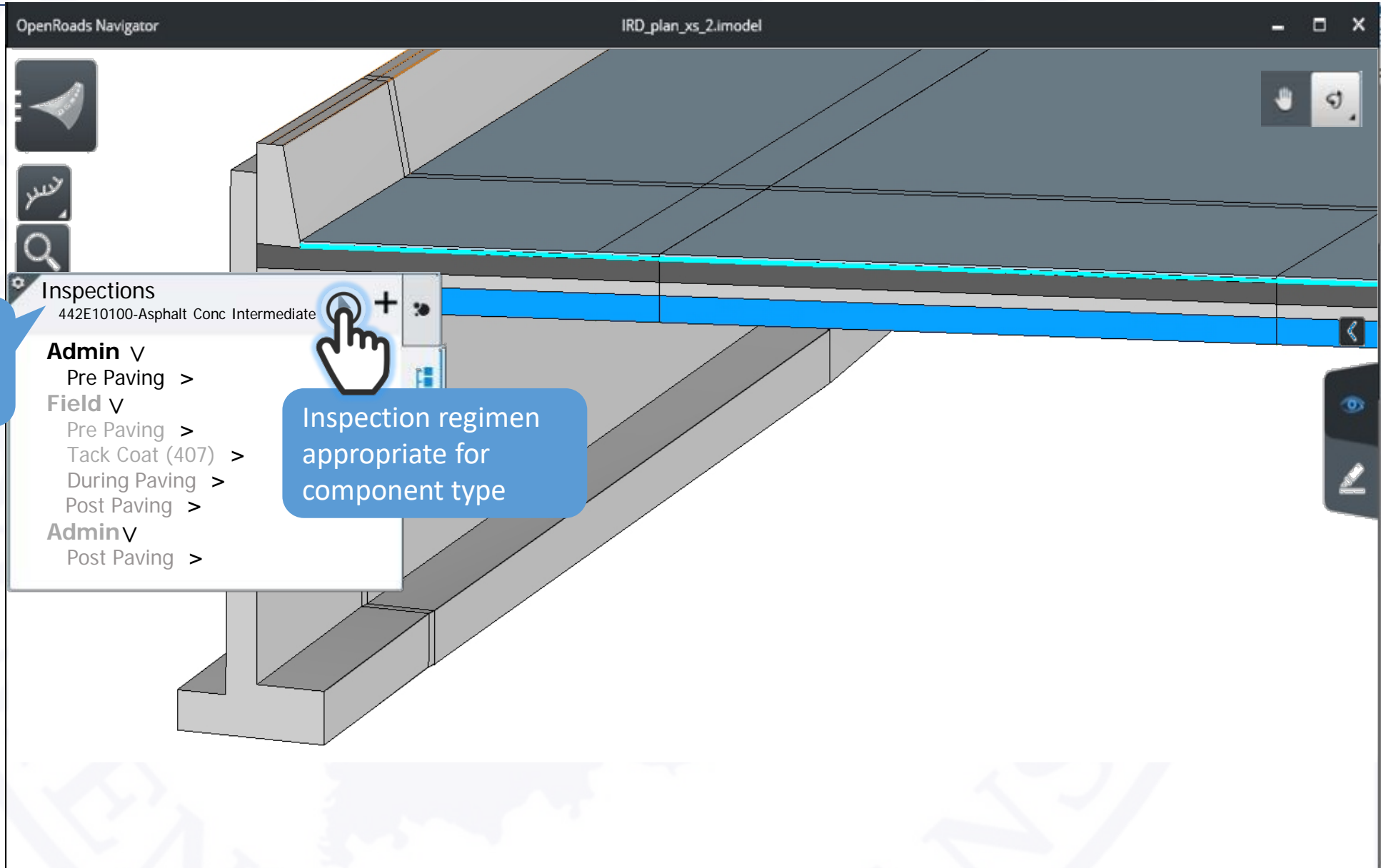
**Note: Field invert elevation checks are required for Types A, B and C Conduits.*

TRENCH & BEDDING CHECKS (ACTUAL FIELD MEASUREMENTS)

Check Stations & Location *	T	W	B	S	O.D.	Initial	Date
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

** Check every 50 feet, with a minimum of two checks per run. Check locations may be related to starting point such as outlet end, catch basin, C/L station, etc.*

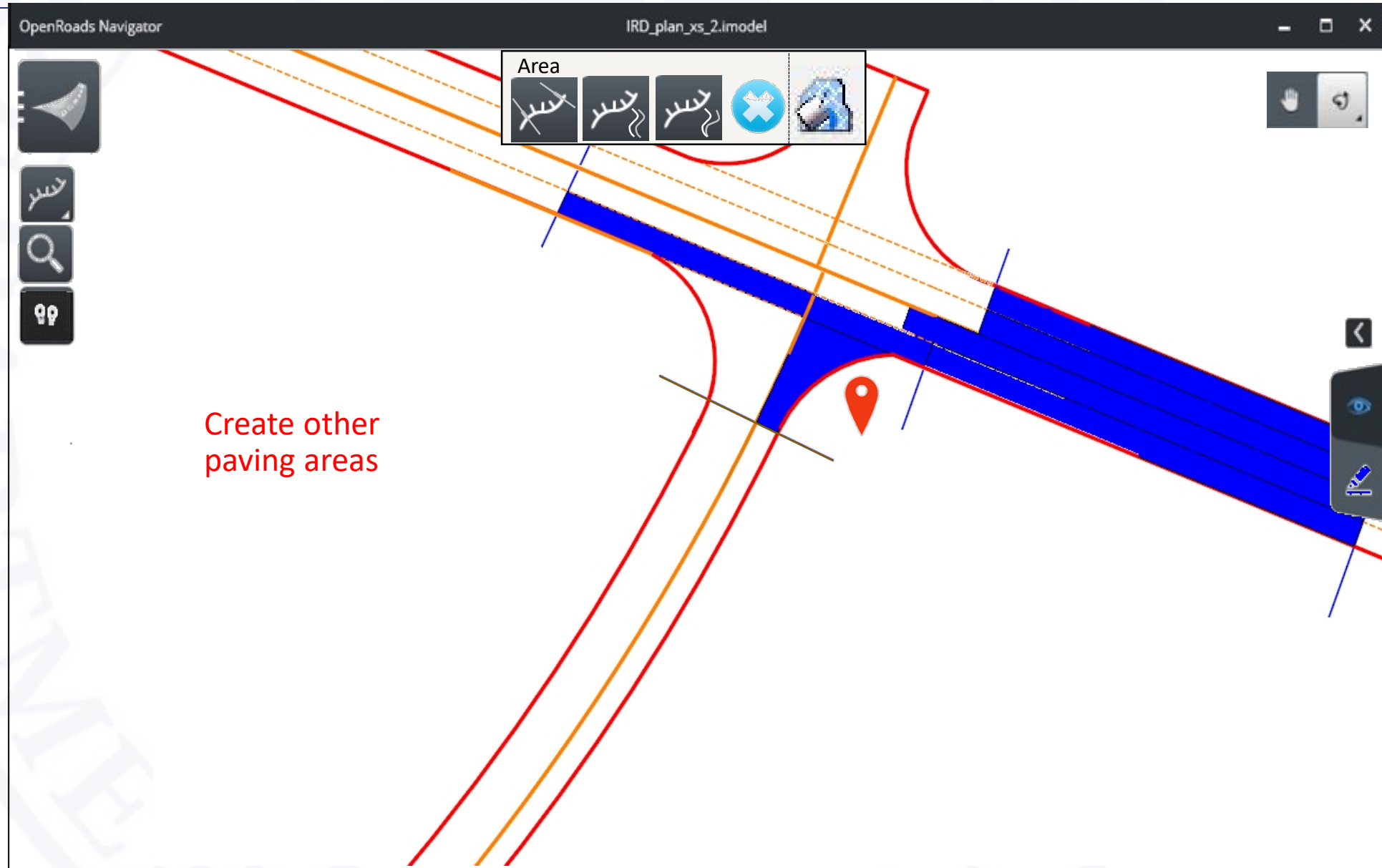
Field Review



Pull out Inspections panel

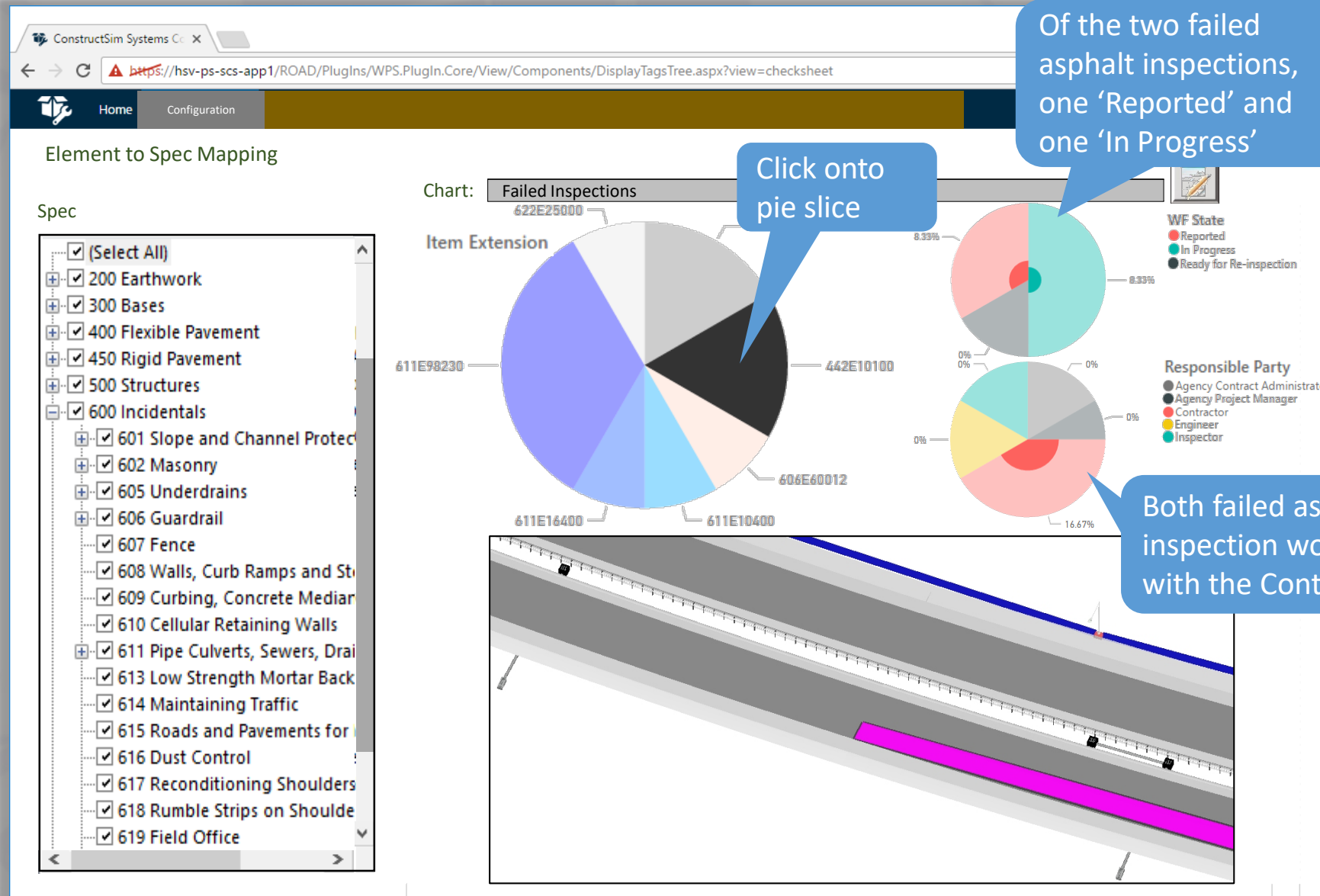
Inspection regimen appropriate for component type

Field Review – New Inspection Geometry Definition



Inspection Office

Inspection Office – Failed Inspections



Inspection Office – Failed Inspections

ConstructSim Systems Co

Home Configuration Project: ROAD

Element to Spec Mapping

Spec

- (Select All)
- 200 Earthwork
- 300 Bases
- 400 Flexible Pavement
- 450 Rigid Pavement
- 500 Structures
- 600 Incidentals
 - 601 Slope and Channel Protec
 - 602 Masonry
 - 605 Underdrains
 - 606 Guardrail
 - 607 Fence
 - 608 Walls, Curb Ramps and St
 - 609 Curbing, Concrete Mediar
 - 610 Cellular Retaining Walls
 - 611 Pipe Culverts, Sewers, Drai
 - 613 Low Strength Mortar Back
 - 614 Maintaining Traffic
 - 615 Roads and Pavements for
 - 616 Dust Control
 - 617 Reconditioning Shoulders
 - 618 Rumble Strips on Shoude
 - 619 Field Office

Chart: Failed Inspections

Item Extension

WF State

- Reported
- In Progress
- Ready for Re-inspection

Responsible Party

- Agency Contract Administrator
- Agency Project Manager
- Contractor
- Engineer
- Inspector

Select element

Chart reflects selected element

Select element



Inspection Office – Failed Inspections

To review failed quality questions, a forms push button appears if single element or single pie slice selected

If chart pie slice selected that represents multiple inspections, scroll arrows become available

Resulting modal shows inspection form

Item 611 Pipe
Design Quantity: 47 m, Measured to Date: 22 m, Paid to Date: 10 m

WF State
● Reported
● In Progress
● Ready for Re-inspection

Responsible Party
● Agency Contract Administrator
● Agency Project Manager
● Contractor
● Engineer
● Inspector

Corresponding element highlights when scrolling through inspection instances



Inspection Office – Failed Inspections

ConstructSim Systems Co

https://hsv-ps-scs-app1/ROAD/PlugIns/WPS.PlugIn.Core/View/Components/DisplayTagsTree.aspx?view=checksheet

Home Configuration Project: ROAD

Element to Spec Mapping

Spec

- (Select All)
- 200 Earthwork
- 300 Bases
- 400 Flexible Pavement
- 450 Rigid Pavement
- 500 Structures
- 600 Incidentals
 - 601 Slope and Channel Protec
 - 602 Masonry
 - 605 Underdrains
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 - 610 Cellular Retaining Walls
 - 611 Pipe Culverts, Sewers, Drai
 - 613 Low Strength Mortar Back
 - 614 Maintaining Traffic
 - 615 Roads and Pavements for
 - 616 Dust Control
 - 617 Reconditioning Shoulders
 - 618 Rumble Strips on Shoulde
 - 619 Field Office

Chart: Photos

Currently selected photo

Currently selected photo

Photo location references



Inspection Office – Status Visualization

Element to Spec Mapping

Chart: Overall – Status Viz Table

Begin Date: _____ End Date: _____

Date	Time	Work Step	Quantity	Unit	Pass/Fail	Comment
6 April 2018	11:33	Aggregate	23855	m3	Pass	
10 April 2018	14:00	Paving	4850	m3	Pass	
11 April 2018	15:45	Paving	3965	m3	Pass	
12 April 2018	10:50	Aggregate	24205	m3	Pass	
13 April 2018	15:15	Paving	1959	m3	Fail	Matt thickness did not conform with the plans

Legend:

- Not Started
- Inspected & Approved
- Inspected & Failed

Callouts:

- Select chart with table that summarizes inspections
- inspection summary table
- Select icon to show inspection form
- Corresponding inspection highlights
- Select element

Quality Checklists - Grouping

Pay Item

715-05053 PIPE, UNDERDRAIN, OUTLET 6 IN. ▼

TRENCHING

INSTALLATION

Check/Info	ID	Description	Section
Information	715-006	Each section of pipe shall have a full firm bearing throughout its length, true to the line and grade given. All pipes which settle or which are not in alignment shall be taken up and re-laid.	715
Information	715-007	Fully bituminous coated and lined pipe and pipe-arches shall only be placed when the ambient temperature is 35°F or above.	715
<input type="checkbox"/>	715-008	Were concrete and clay pipe laid with hub upgrade, with the spigot end fully extended into the adjacent hub, and with all ends fitted together tightly?	715

[Show More](#)

BACKFILL

COMPACTION

Quality Checklists - Cross Referencing

Pay Item

203-02055 EMBANKMENT

- 203-016 Were shale, shale and soft rock mixtures, or soft rock placed in 8 in. maximum loose lifts?
- 203-030 If embankment for new pavement is to be placed over existing roadbeds, were removal of the surfacing material, breaking the base, and disposal of removed material in accordance with 202.05?

Check Result	ID	Description	Section
<input checked="" type="checkbox"/>	202-009	Pavement layers or courses removed as indicated in plan?	202
<input checked="" type="checkbox"/>	202-010	Concrete walks and steps removed as indicated in plans?	202
<input checked="" type="checkbox"/>	202-011	Concrete curbs and gutters or stone curbs removed as indicated in plans?	202

[Show More](#)

...

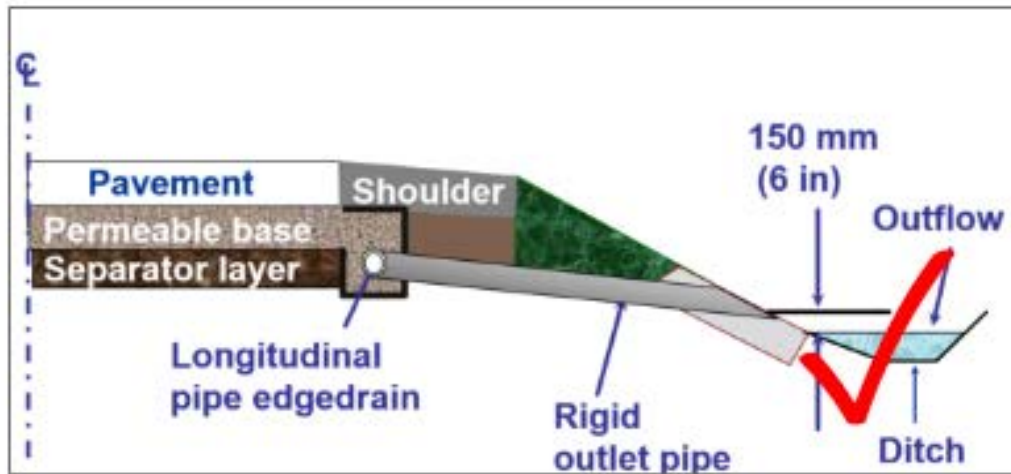
Quality Checklists – Pictures or Videos

Pay Item

715-05053 PIPE, UNDERDRAIN, OUTLET 6 IN.

⊕ ...

- 715-047 Precast innots shall be cast as a single complete unit except for the toewall which shall be cast in place and they shall be set and leveled on a 6 in. thick bed of coarse aggregate



Questions?

- Contact Information:

- Derek Fuller: DFuller@indot.IN.gov
- Chris Martin: CMartin@indot.IN.gov
- Andrew Pangallo: APangallo@indot.IN.gov

